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DIFFERENTIAL RESPONSE OF SORGHUM CULTIVARS FOR FODDER YIELD AND QUALITY

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Forage shortage is one of the main reason for lower meat and milk production in the country. Various forages like sorghum, millet and Guar are grown to fulfill the dietary needs of the animals in summer season. Among these fodders, sorghum is of prime importance. Different sorghum cultivars differ in growth, yield, morphology and quality attributes. This experiment was aimed to evaluate the comparative performance of different sorghum forage cultivars regarding its yield and quality attributes. The experiment was conducted at the Post Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad, Pakistan during 2012. Eight forage sorghum cultivars viz. JS-2002, JS-263, MR-Sorghum-2011, Hegari, Pak-China-1, Sandal Bar, F-7017 and F-114 were sown in randomized complete block design with four replications having net plot size of 3m × 6m. The crop was shown on April 30, 2012. Recommended dose of fertilizer was applied. Three irrigations were applied during entire growth period of the crop. The crop was harvested when crop was at 50% heading. Sorghum cultivars differed in forage yield, dry matter yield, morphological traits and quality parameters. Maximum plant height, stem diameter, leaf weight per plant, leaf area per plant, fresh weight per plant, dry weight per plant, forage yield, dry matter yield and ash percentage were recorded in Pak-China-1 followed by F-114. Plant height, number of leaves per plant and plant population per unit area was minimum in Sandal-Bar. Crude protein and crude fiber were more in Sandal bar and F-7017 respectively as compared to other varieties.
Keywords: Sorghum; Animal nutrition; Proteins; Forage; Cultivars

INTRODUCTION

Livestock being an important sector of agriculture plays an important role in the rural economy of Pakistan. The share of livestock in value addition is 53.2% out of total agricultural value added while its contribution in GDP is 11.4% (Govt. of Pak., 2012). In Pakistan, low fodder production and lower availability of feed are important factors contributing towards the minimum livestock throughout the country. Livestock production can be improved by providing them with proper quantity and quality of animal feed. Currently, our fodder production meets 30-50% of the total fodder requirement of the country. Minimum milk and meat yields are the result of poor feeding of animals (Amanullah *et al.,* 2007). In Pakistan, fodder crops covered an area of 2235.9 thousand ha and provided 49235.1 thousand tonnes of green fodder (Agriculture Statistics of Pakistan, 2011). Fodders supply provides 2-3 times cheaper feed than concentrates. Various factors such as climate, cropping pattern, livestock type and socio-economic conditions affect the production and utilization of fodder in a given locality. The animals mostly the buffaloes and cattle are fed on the forage which is harvested from the cultivated lands while sometimes these are also fed on top feeds and harvested grasses.

Sorghum has been domesticated since approximately 3000 years B.C. in the Ethiopia region (Ayana and Bekele, 1999). It (*Sorghum bicolor* L.) is ranked as first cereal crop of kharif season in many parts of the world including Pakistan which also serves as fodder for many kinds of animals. It usually exhibits rapid growth and provides large quantities of grain as well as fodder in very short time (Amanullah *et al.,* 2007). Its fodder contains 7 to 12% protein, 70% carbohydrates, minerals, crude fat and nitrogen free extract. In Pakistan, it is grown on an area of 228.8 thousand hectares with the production of 141.2 thousand tones (Agriculture Statistics of Pakistan, 2010-2011).

Not only dry matter yield is important but quality and quantity of fodder is also much important. Therefore, it is an urgent need to produce high yielding varieties of fodder crops to fulfill the livestock demands (Chohan *et al.,* 2006). Ahmad *et al.* (1993) argued that fodder shortage in scarcity periods can be minimized by introducing higher producing fodder varieties. Among different possibilities to fulfill the forage shortage as happens in our country, the most pragmatic option is the growing of those varieties which have high fodder yield (Bilal *et al.,* 2001; Chohan *et al.,* 2006). Different sorghum cultivars vary in fodder yield as well as quality of fodder (Sarfraz *et al.,* 2012). Ayub *et al.* (1999) found higher yield of green fodder as well as dry fodder in sorghum cultivar viz. Hegari. That was due to enhanced plant height and greater stem diameter of this variety. In another study Ayub *et al.* (2010) also found that different sorghum varieties differ in their yield potential.

So this study was carried out to find the best sorghum cultivar which can perform better in terms of forage yield and dry matter production under irrigated conditions and determination of forage quality of different sorghum cultivars was also an important aspect of this study.

MATERIALS AND METHODS

This experiment was conducted at the Post Graduate Agricultural Research Station, University of Agriculture, Faisalabad, Pakistan during the year, 2012. Experimental site lies between 30.35-41.47°N latitude and 72.08-73.40°E longitude at an elevation of 184.4 m above sea level. Seeds of all sorghum cultivars used in this study were obtained from Fodder Research Institute, AARI, Faisalabad. After applying the pre-sowing irrigation of 10 cm, seedbed was uniformly prepared for all the experimental units by giving three cultivations with the help of a tractor-mounted cultivator each followed by planking. The cultivation was done to a depth of 12 cm. The crop was sown on April 30, 2012 with single row hand drill in 30 cm apart rows using a seed rate of 75 kg ha^{-1}. Recommended dose of fertilizer (80 kg N and 60 kg P_2O_5 ha^{-1}) was applied. Urea (46%) and DAP (46% P and 18% N) were used as sources of fertilizer. Half dose of nitrogen and full dose of phosphorous and potassium was applied at the time of seed bed preparation while the remaining half nitrogen was applied at time of second irrigation. Three irrigations each of 7.5 cm were given during the entire growth period of the crop. The first irrigation was given 21 Days after Sowing (DAS) and second after 35 DAS and third at full vegetative stage. The crop was harvested on 65 DAS with hand sickle when the crop reached to 50% heading stage. All other agronomic practices were kept normal for all experimental units. The experiment was executed in Randomized Complete Block Design with four replications having net plot size of 3m × 6m. The experiment consists of treatments Viz. T_1= Jawar-2002; T_2= Jawar-263; T_3= MR-Sorghum-2011; T_4= Hegari; T_5= Pak-China-1; T_6= Sandal Bar; T_7= F-1017; T_8= F-114.

All the agronomic, forage yield and quality related parameters were recorded following stand procedure. The numbers of sorghum plants were counted in square meter of three randomly selected places in each plot and then average of per square meter plants were noted. From each plot randomly ten sorghum plants were selected and their height was measured from the base to the tip of the plant with measuring tape and then averaged. The diameter of ten randomly selected plants from each plot was measured with the help of Vernier Caliper from the base, middle and top portions of the stem and then average was calculated. Total number of leaves from ten plants was counted and then average leaves per plant were calculated. Ten plants from each plot were selected randomly and their leaves were removed and weighed. Then a sub sample of 10g was kept over the screen of leaf area meter (Licor model 3100) to record leaf area. Then this leaf area was used for calculating leaf area per plant. Fresh weight of ten plants from each plot was recorded and then average fresh weight per plant was computed. The plants were shade dried before putting in oven at 70°C until constant dry weight. Afterwards the dry weight per plant was calculated. All the crop plants, in each net plot reserved for recording yield at final harvest, were harvested and weighed separately with the help of a spring balance and then converted into t ha^{-1}.

At final harvest, ten randomly selected plants from each plot were chopped with the help of fodder cutter and then thoroughly mixed. Fresh weight of the sample was recorded. Thereafter, a sample of 500g was taken from each lot and dried in an oven at 70°C to a constant dry weight. Dry weight of the samples was then measured with electronic balance. After that dry matter was calculated by using the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

The crude protein (%), crude fiber (%) and total ash percentage was determined by using standard procedure as proposed by AOAC (1990). Data collected on all parameters were analyzed statistically by using MSTAT-C software on computer (Crop and Soil Sciences Department of Michigan University of the United States). Least Significance Difference (LSD) test at 5% probability level was applied to compare the treatments means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Analysis of variance indicated that agronomic, forage yield and quality, traits were significantly different in all the sorghum cultivars (Table 1). Maximum plant population at harvest was observed in Jawar-263 which was followed by F-7017, MR-Sorghum-2011, F-114, Pak-China-1 and Jawar-2002, respectively (Table 2). While the minimum plant population was observed in Sandal-Bar. Similarly, means comparison of different sorghum cultivars revealed that maximum plant height was observed in Pak-China-1 followed by F-7017, MR-Sorghum-2011, Hegari, Jawar-2002 and Jawar-263, respectively whereas, the minimum plant height was observed in Sandal bar as compared to other sorghum cultivars. Likewise, Sorghum cultivar Pak-China-1 showed maximum stem diameter followed by Sandal Bar, MR-Sorghum-2011, F-114, F-7017 and Hegari, respectively (Table 2). Minimum stem diameter was observed in Jawar-2002. In this study, maximum number of leaves per plant were observed in Pak-China-1 which was followed by F-114, MR-Sorghum-2011, Jawar-2002, F-7017 and Hegari, respectively (Table 2). While the minimum number of leaves per plant were observed in Sandal bar which was statistically at par with F-7017 and Hegari cultivars regarding number of leaves per plant. Data pertaining to leaf weight per plant revealed that cultivar Pak-China-1 exhibited maximum leaf weight per plant when compared with other sorghum cultivars and was followed by F-114, Hegari, MR-Sorghum-2011 and Sandal-Bar, respectively (Fig. 4.5; Table 4.5 B). Minimum leaf weight per plant was observed in Jawar-2002. Leaf area per plant

was highest in Pak-China-1 which was then followed by F-114, Sandal-Bar, MR-Sorghum-2011, F-7017 and Jawar-263, respectively (Table 2). Sorghum cultivar Jawar-2002 gave minimum leaf area per plant as compared to other sorghum cultivars. Moreover, sorghum cultivar viz. Pak-China-1 yielded maximum fresh weight per plant followed by F-114, MR-Sorghum-2011, Sandal-Bar, F-7017 and Jawar-263, respectively (Table 2). Whereas, sorghum cultivar Jawar-2002 produced the least fresh weight per plant than other sorghum cultivars. Among different sorghum cultivars, maximum dry weight per plant was observed in Pak-China-1 followed by F-114, F-7017, MR-Sorghum-2011, Sandal-Bar and Jawar-263, respectively while it was minimum in Jawar-2002 than other sorghum forage cultivars. Among different sorghum cultivars, Pak-China-1 exhibited maximum fresh forage yield followed by F-114, Sandal-Bar, Hegari, Jawar-263, Jawar-2002 and F-7017, respectively whereas, the least fresh forage yield was observed in MR-Sorghum when compared with other sorghum forage cultivars. Similarly, different sorghum cultivars varied significantly regarding dry matter yield and maximum dry matter yield was observed in Pak-China-1 followed by F-114, Sandal-Bar, Hegari, MR-Sorghum-2011 and Jawar-263, respectively while the minimum dry matter yield was observed in Jawar-2002 as compared to other sorghum cultivars.

Sorghum cultivars varied significantly regarding percent protein contents and maximum crude protein contents were observed in Sandal bar which was followed by Pak-China-1, F-114, MR-Sorghum-2011, F-7017 and Jawar-263, respectively (Table 2). However, the minimum crude protein contents were observed in Hegari cultivar when it is compared with other sorghum cultivars. Maximum crude fiber contents were observed in F-7017, F-114 and Hegari, respectively while sorghum cultivar Pak-China-1 yielded the least crude fiber contents. Likewise, maximum ash percentage was observed in Pak-China-1 followed by F-114, Sandal-Bar, Hegari, Jawar-2002 and Jawar-263, respectively. Minimum ash percentage was observed in MR-Sorghum when compared with other sorghum cultivars.

Maximum plant population at harvest was observed in Jawar-263 followed by F-7017, MR-Sorghum-2011, F-114, Pak-China-1 and Jawar-2002, respectively (Table 2). While it was minimum in Sandal-Bar. Difference in plant population per unit area of different sorghum cultivars may be due to difference in seed viability or difference in grain weight of these cultivars. In an earlier study, Ayub *et al.* (2010) also found significant difference in plant population per unit area of different forage sorghum cultivars (JS-88, F-9603, JS-263, F-9806, Hegari, JS- 88, F-9601, F-9706, and F-9809). In our study we observed maximum plant height in Pak-China-1 followed by F-7017, MR-Sorghum-2011, Hegari, Jawar-2002 and Jawar-263, respectively whereas, the minimum plant height was noticed in Sandal bar than other sorghum cultivars. Difference in plant height in different forage sorghum cultivars may be due to variation in genetic makeup of these various varieties. In earlier studies, Muhammad *et al.* (2002), Mehmud *et al.* (2003), Yousef *et al.* (2009) and Hussain *et al.* (2011) also reported differences in plant height of different sorgum cultivars. Likewise, Sorghum cultivar Pak-China-1 produced maximum stem diameter followed by Sandal Bar, MR-Sorghum-2011, F-114, F-7017 and Hegari, respectively (Table 2), while minimum stem diameter was observed in Jawar-2002. The difference in stem diameter of these forage sorghum cultivars may also be due to difference in the genetic makeup of these varieties. In a previous study Ayub *et al.* (2010) also found significant difference in stem diameter of eight sorghum cultivars. In another study, Nabi *et al.* (2006) compared five sorghum varieties and found significant differences in stem diameter of sorghum cultivars.

We observed maximum number of leaves per plant in Pak-China-1 followed by F-114, MR-Sorghum-2011, Jawar-2002, F-7017 and Hegari, respectively (Table 2). While the minimum number of leaves per plant were observed in Sandal bar which was statistically at par with F-7017 and Hegari cultivars. This variation in leaf number per plant in different varieties may be due to their intermodal distance as well as the plant height may also influence the number of leaves per plant. Earlier, differences in number of leaves per plant in different sorghum cultivars have been reported (Muhammad *et al.*, 2002; Zulfiqar *et al.*, 2002; Chohan *et al.*, 2003; Amanullah *et al.*, 2007).

Data pertaining to leaf weight per plant revealed that cultivar Pak-China-1 exhibited maximum leaf weight per plant than other sorghum cultivars followed by F-114, Hegari, MR-Sorghum-2011 and Sandal-Bar, respectively (Table 2). Minimum leaf weight per plant was observed in Jawar-2002. Maximum Leaf weight per plant in Pak-China-1 and F-114 may be due to more number of leaves per plant as were observed in both these forage sorghum cultivars. Similarly less leaf weight in JS-2002 and F-7017 may be due to less leaves number plant in both these cultivars. Maximum leaf weight per plant in these cultivars may also be due to increased leaf area in these cultivars. If a plant produces more and larger leaves then its leaf weight will be higher as compared to other plant that has produced less and shorter leaves. In this experiment, Pak-China-1 produced more and larger leaves per plant so its leaf weight per plant was height as compared to other forage sorghum cultivars used in this study. In this study, we found maximum leaf area per plant in Pak-China-1 followed by F-114, Sandal-Bar, MR-Sorghum-2011, F-7017 and Jawar-263, respectively (Table 2). Maximum leaf area in Pak-China-1 and F-114 may be due to more number of leaves per plant while minimum leaf area in JS-2002 and Hegari may be due to less number of leaves per plant in these cultivars. Difference in leaf area per plant may be due to genetic variation among these forage sorghum cultivars. Chohan *et al.* (2003) also reported significant difference in leaf area of different sorghum cultivars. Similarly, Amanullah *et al.* (2007) found differences in the leaf area of ten sorghum cultivars.

Moreover, sorghum cultivar viz. Pak-China-1 yielded maximum fresh weight per plant followed by F-114, MR-

Table 1: Analysis of variance for the agronomic, forage yield and quality related traits of various forage sorghum (*Sorghum bicolor* L.) cultivars

Source of variation	Degree of freedom	Plant population (m^2)	Plant height (cm)	Stem diameter (cm)	Leaves per plant	Leaf weight per plant (g)	Leaf area per plant (cm^2)	Fresh weight per plant (g)	Dry weight per plant (g)	Fresh forage yield ($t\ ha^{-1}$)	Dry matter yield ($t\ ha^{-1}$)	Crude protein (%)	Crude fibers (%)	Ash (%)
Replication	3	26.3	631.2	0.08	0.59	18.6	18904	5644.4	108.3	163.5	5.0	0.010	0.03	0.20
Treatments	7	2084.5**	2010.3**	0.57**	2.35**	1335.6**	141938**	26220.9**	923.7**	1305.5**	330.3**	3.730**	2.62**	3.77**
Error	21	82.1	181.0	0.03	0.25	42.7	4553	3600.0	175.5	92.8	26.3	0.002	0.01	0.08
Total	13													

Table 2: Agronomic, forage yield and quality related traits of various forage sorghum (*Sorghum bicolor* L.) cultivars

Treatments	Plant population (m^2)	Plant height (cm)	Stem diameter (cm)	Leaves per plant	Leaf weight per plant (g)	Leaf area per plant (cm^2)	Fresh weight per plant (g)	Dry weight per plant (g)	Fresh forage yield ($t\ ha^{-1}$)	Dry matter yield ($t\ ha^{-1}$)	Crude protein (%)	Crude fibers (%)	Ash (%)
Jawar-2002	93 cd	249.3 cd	1.41 d	14.7 bc	27.5 f	2631 d	177 e	39 c	65 bc	21 d	4.33 h	32.79bc	8.09 bc
Jawar-263	141 a	249.0 cd	1.87 c	14.1 cd	45.7 de	2784 c	267 cd	44 bc	66 bc	25 cd	4.65 f	33.54 b	7.90 c
MR-Sorghum-2011	129 ab	264.3 bc	2.02 c	14.8 bc	53.5 cd	2916 b	350 bc	59 b	55 c	27 cd	5.42 d	32.21 c	5.51 d
Hegari	84 d	264.3 bc	1.82 c	14.2 cd	56.3 bc	2674 d	250 de	49 bc	69 b	29 bc	3.91 i	33.83 a	8.26 abc
Pak-China-1	97 c	311.7 a	2.66 a	16.3 a	87.8 a	3223 a	440 a	89 a	107 a	49 a	6.42 b	32.13 c	8.52 a
Sandal-Bar	82 d	243.7 d	2.35 b	13.9 d	48.5 cd	2938 b	283 bcd	57 bc	72 b	30 bc	6.64 a	32.14 c	8.32 ab
F-7017	130 ab	270.7 b	1.97 c	14.3 bcd	37.3 e	2787 c	283 bcd	61 b	59 bc	21 d	4.91 e	33.86 a	7.91 c
F-114	118 b	244.7 cd	2.01 c	15.0 b	65.0 b	2959 b	367 ab	62 b	95 a	35 b	5.54 c	33.85 a	8.32 ab
LSD Value (p 0.05)	13.32	19.78	0.24	0.73	9.61	99.22	88.23	19.48	14.17	7.55	0.07	0.11	0.41

Sorghum-2011, Sandal-Bar, F-7017 and Jawar-263, respectively (Table 2). Whereas, sorghum cultivar Jawar-2002 produced the least fresh weight per plant than other sorghum cultivars. Plants are autotrophs and they prepare their own food through process of photosynthesis and leaves are the photosynthetic machinery for plant. If a plant has larger and more leaves, definitely it has more photosynthesis and more vigorous plants. As more number of leaves and larger leaves were observed in Pak-China-1, it might be resulted in more fresh weight per plant of this variety. Similarly, less plant weight in JS-2002 may be due to less and shorter leaves per plant which might have less photosynthesis as compared to the varieties which have more and larger leaves with high fresh plant weight. The findings of Tariq *et al.* (2012) are in line with these results who studied 25 different sorghum genotypes for different parameters and they observed significant differences in fresh weight per plant of all these cultivars.

Among different sorghum cultivars, maximum dry weight per plant was observed in Pak-China-1 followed by F-114, F-7017, MR-Sorghum-2011, Sandal-Bar and Jawar-263, respectively while it was minimum in Jawar-2002 than other sorghum forage cultivars. In a recent study Tariq *et al.* (2012) observed significant differences in dry weight per plant of 25 sorghum cultivars. Earlier, Muhammad *et al.* (2002) also reported significant variation among different sorghum cultivars regarding dry weight per plant.

We observed maximum fresh forage yield in Pak-China-1 followed by F-114, Sandal-Bar, Hegari, Jawar-263, Jawar-2002 and F-7017, respectively whereas the least fresh forage yield was observed in MR-Sorghum than other sorghum forage cultivars. More fresh forage yield in Pak-China and F-114 may be due to more stem diameter, more number of leaves per plan and more leaf area per plant and more fresh weight per plant in these cultivars. Our results regarding fresh forage yield are well supported by the findings of Amanullah *et al.* (2007) who found significant variation among ten sorghum cultivars for fresh forage yield. Likewise, Chohan *et al.* (2003) conducted a study and reported significant differences in the fresh forage yield of ten sorghum cultivars. Ayub *et al.*, (2010) and Hussain *et al.* (2011) also reported significant differences in the fresh forage yield of various sorghum forage cultivars. Similarly, maximum dry matter yield was observed in Pak-China-1 followed by F-114, Sandal-Bar, Hegari, MR-Sorghum-2011 and Jawar-263, respectively; while the minimum dry matter yield was observed in Jawar-2002 than other sorghum cultivars. More dry matter yield in Pak-China-1 and F-114 may be due to increase in forage yield of these cultivars. The results of current study are in well support by the findings of Amanullah *et al.* (2007) who compared ten sorghum cultivars and found statistically significant difference among these cultivars regarding dry fodder yield where he obtained maximum dry fodder yield in JS-88 as compared to other varieties. Ayub *et al.* (2010) also carried out a study to evaluate the comparative fodder yield performance of eight sorghum cultivars and found maximum dry fodder yield in F-9603.

Sorghum cultivars varied significantly regarding percent protein contents and maximum crude protein contents were observed in Sandal bar which was followed by Pak-China-1, F-114, MR-Sorghum-2011, F-7017 and Jawar-263, respectively (Table 2). However, the minimum crude protein contents were observed in Hegari cultivar than other sorghum cultivars. These results are in line with the findings of Sarfraz *et al.* (2012), who reported significant differences among sorghum cultivars regarding protein contents. Similar results were also reported by Yousef *et al.* (2009), who found that crude protein contents were different in two sorghum cultivars. Likewise, in a recent study, Ayub *et al.* (2012) checked seven lines of sorghum for quality parameters and they reported variation in protein contents of these lines.

In this study, maximum crude fiber contents were observed in F-7017, F-114 and Hegari, respectively while sorghum cultivar Pak-China-1 yielded the least crude fiber contents. The findings of Ayub *et al.* (2010), who reported that all eight varieties differed significantly in crude fiber contents and maximum crude fiber contents, were found in Hegari. Panwar *et al.* (2000), Hunsigi *et al.* (2010) and Ayub *et al.* (2012) also reported differences in the crude fiber contents of various sorghum cultivars.

We found maximum ash percentage in Pak-China-1 followed by F-114, Sandal-Bar, Hegari, Jawar-2002 and Jawar-263, respectively, while minimum ash percentage was observed in MR-Sorghum than other sorghum cultivars. Difference in ash percentage in different sorghum cultivars may be due to variation in genotypes to absorb different nutrients from soil which depends on rooting pattern of that variety. These results are in accordance with findings of Ayub *et al.* (2010) who found that ash percentage was significantly different in various sorghum cultivars. In a recent study, Ayub *et al.* (2012) reported that ash percentage significantly varied among different sorghum cultivars.

CONCLUSION

This study indicates that the performance of Pak-Chian-1 and F-114 was best among all the studied varieties in terms of forage yield and dry matter production. Both these varieties produced bigger plants, more leaves and thicker stem than other varieties which resulted in increased forage and dry matter yield while crude protein and crude fiber were more in Sandal bar and F-7017 respectively than other varieties.

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